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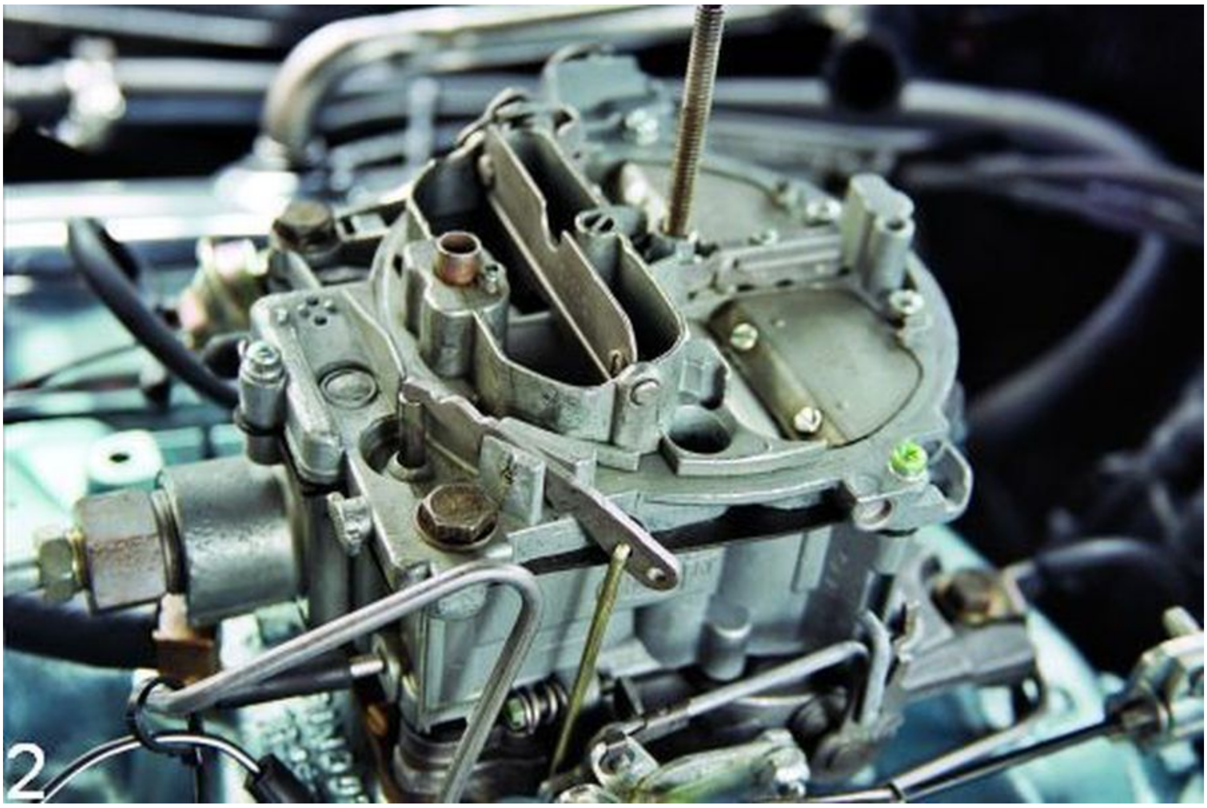
The Lost Art of Choke Adjustment

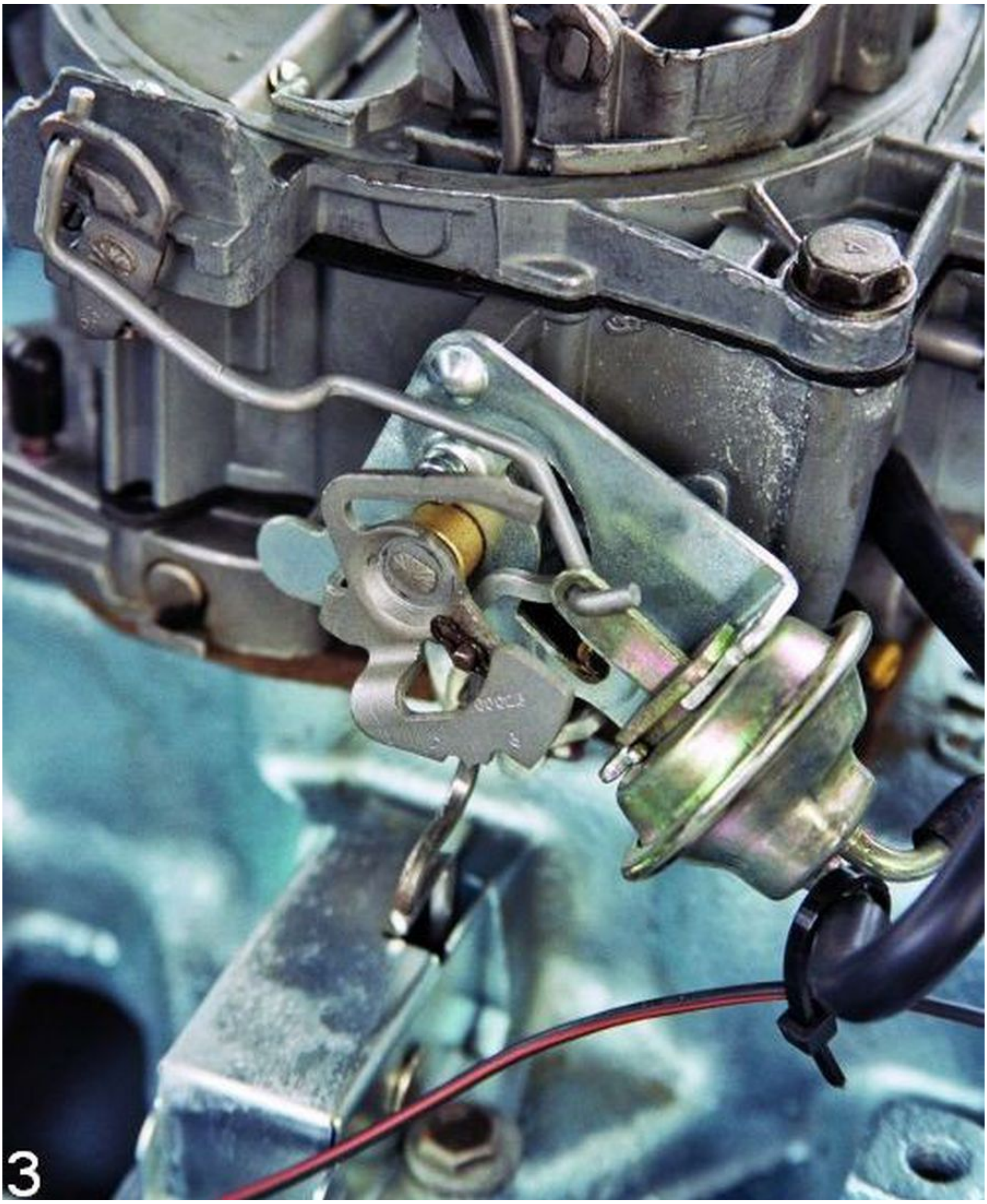
In This Article

Approximately 25 years ago, when electronic fuel injection started showing up on new cars, one of its selling points was the elimination of cold-start issues blamed on the carburetor. That mindset always confused me: All of my carburetor-equipped vehicles started and ran flawlessly, regardless of the weather or ambient temperature. But there was a caveat attached to that reliability: The choke had to be adjusted properly, and the manufacturers never pointed this out when talking about EFI versus carburetion. In its rush to move to EFI, the auto industry was throwing the faithful carburetor under the tires of the proverbial bus, and for no good reason.

To this day, many enthusiasts believe that a carburetor-equipped engine will be hard to start on a cold day, that it will act balky during warm-up and generally not drive like a modern car until it reaches operating temperature. This could not be further from the truth, and this misperception was the impetus for this installment in the Lost Art series.



Understanding the Choke During engine crank on a cold start, a number of issues arise due to the temperature of the air and the engine itself, along with the slow speed of the pistons. Gasoline needs heat to vaporize, and as the ambient temperature drops, so does the rate of vaporization. At -45 degrees Fahrenheit, only 20 percent of the fuel will vaporize; under those conditions, a gasoline-powered engine will not start without an external heat source. At 60 degrees, the rate of vaporization is only 50 percent. Additionally, the speed at which the engine cranks is a concern; low piston velocity will not create a significant amount of depression--a low-pressure state--which, in turn, will fail to evoke enough fuel flow to overcome the poor vaporization rate.



Without a way to enrich the mixture, the fuel mixture that reaches the cylinders during crank is too lean to ignite; until the intake manifold reaches a certain temperature, the fuel distribution would suffer. To produce fast cold starts and acceptable engine operation during engine warm-up, the carburetor uses a choke to enrich the air/fuel ratio.
The choke consists of a butterfly or plate located in the air horn. The first choke systems were manually operated, using a cable controlled by the driver from inside the vehicle. The operator had to remember to cancel the function gradually as the engine built coolant temperature. An automatic choke adds a few components to the basic butterfly: a thermostatic spring and a fast-idle cam. In contrast to the manual choke, it does not require any driver input to set the air/fuel ratio.

The Components The choke circuit consists of the butterfly or choke plate, the pull-off (also called a vacuum break), the choke spring, and the fast-idle cam and screw.
Butterfly: The choke plate should fully and easily close against the air horn when the throttle is opened slightly and the spring has tension on it. The butterfly also needs to be able to open as the thermostatic spring tension is released. If it does not perform properly and there is no issue with the linkage or from varnish buildup, then the air horn is most likely warped from over-tightening.
Pull-off or break: The pull-off is manifold vacuum-operated and is designed to open the choke plate slightly after the engine starts, to decrease the signal at the booster. It pulls the choke plate open against spring tension. Some Rochester carburetors had a primary and secondary pull-off that allowed more control over the opening function. Some carburetors did not employ a break, but instead had a notch machined into the butterfly.
Spring: The choke spring can be either integral (a part of the carburetor), such as the design used on the later Rochester Quadrajet, or divorced (not attached to the carburetor), which was common on Chrysler products. When divorced, a linkage connects the spring to the choke plate. The choke spring is typically a coiled, bi-metallic design, using two strips of dissimilar metals (usually steel and copper or brass) joined back-to-back. The difference in the metals' thermal expansion rates causes the coil to unwind as heat is introduced, yielding the spring tension necessary to actuate the choke mechanism gradually. Upon cooling, the spring contracts back into a tighter coil.

Heat can be introduced to the choke spring from the engine using various means. Most integral choke housings were fed hot air via a small feed-tube that led from a source on the intake manifold's heat-riser exhaust crossover. In contrast, most divorced choke springs sat in a well in the heat-riser passage in the intake manifold.
In the mid-1970s, electric choke springs were introduced. These used a 12-volt heating element, much like a low-powered toaster, in place of hot air. Chrysler employed an electrically assisted choke during that time. This system still used engine heat from the intake manifold, but had a very low-powered electric element that hastened choke engagement as an early method of emissions control.
Fast-idle mechanism: The fast idle is controlled by a stepped cam and usually employs a fast-idle screw that keeps the throttle opened when choke spring tension is created. Some applications did not use a dedicated fast-idle screw and instead had the curb idle speed screw ride against the cam. This style was not common, and did not allow enough freedom in adjustment of the fast-idle speed, since it would be a function of the curb idle setting.
For the choke circuit to function properly, the rest of the carburetor needs to be mechanically sound. It should be clean, tight (both its fasteners and those that attach it to the intake manifold) and its float level and idle mixture screws should be set correctly. The fast-idle speed is very critical to the engine's performance during warm-up because this, along with the pull-off specification, determines the amount of "blow-off" the choke plate experiences. If the choke plate does not open enough, after startup the engine will load up, blow black smoke from the tailpipe(s) and possibly stall and flood.
Automatic Choke Startup As mentioned earlier, an automatic choke does not require driver intervention in order to set the proper air/fuel ratio. What it does need is the proper starting procedure to set the choke butterfly in the closed position.
An automatic choke closes against spring pressure. During engine crank, it then exposes almost full manifold vacuum to the carburetor venturi, drawing a large amount of fuel through the main metering system. When the engine fires, the increased piston velocity partly blows the choke plate open against spring tension to allow a sufficient amount of air to lean the mixture by reducing the depression in the venturi. As the engine warms up, the spring tension is reduced until the butterfly is completely open and has no impact on the signal the carburetor venturi (booster) is exposed to.
When a hot engine is shut off and starts to cool, the tension on the choke spring increases in lockstep with the drop in temperature. The choke plate

and fast-idle cam are attached to the spring via the carburetor's throttle linkage. This requires the throttle to be pressed slowly to the floor once to allow the choke plate to close, and needs to be done prior to cranking the engine over. When functioning properly, the full depression of the accelerator pedal will release the choke spring tension being held by the fast-idle cam and screw, while also providing a shot of fuel into the manifold by the accelerator pump. The accelerator pump shot works as a small prime pulse to provide a combustible mixture prior to the fuel being discharged by the venturi booster.

When cranking the engine, you do not want to "pump" the throttle, since this will decrease the signal to the booster and limit or stop fuel flow. If the engine does not start when cranked over for a few seconds, release the key and press the accelerator to the floor one more time to evoke an additional accelerator pump shot.

Most automatic chokes have a "clear flood" mode or "unloader" that is carburetor-linkage operated. If the engine does not start and becomes flooded, holding the accelerator to the floor will force the choke plate open, which will decrease the booster signal and provide more air to lean the mixture.

As the engine warms up, the choke spring tension will be reduced; if the accelerator is moved slightly open, the fast-idle cam will drop a notch and move toward curb (warm) idle RPM. You do not want to aggressively throttle the engine to get the fast idle to drop. As the spring tension is released, the pedal only needs to be moved enough to allow the fast-idle screw to clear the next step in the cam.

If the idle speed does not want to drop, the choke has not received enough heat to relax from that position. You do not want to "blow it open" by whacking the throttle hard, which brings us to a significant point: Many cold-start issues are simply driver error and not a problem with the choke circuit.

Diagnostics The first step in any choke adjustment procedure is to locate the proper specifications for your car from a factory shop manual.

Most earlier pull-off specifications were keyed to a drill bit size, while later Rochester carburetors used a more exact choke angle gauge, as seen in this primer.

The following troubleshooting tips are based on an otherwise correctly tuned engine, where the choke circuit has been determined to be the cause of the problem. The stated symptom can only be applied to a condition that calls for the choke to be evoked (not a hot engine problem).

Hard starting: Check to verify that the choke plate is closing fully when the gas pedal is tapped and that the plate maintains spring tension when closed. If the choke does not close, then either the linkage is gummed up, the air horn is warped, or the spring tension is too loose or the choke spring has experienced a failure such as an internal break.

Starts and stalls within a few seconds: If the choke plate closes properly and the engine starts and stalls almost immediately, the issue is usually not choke-related. This condition is likely the result of the carburetor float bowl losing fuel when the engine is turned off. The needle valve may be leaking under the gasket or the bowl may have a leak that drains it. This was common with Rochester carburetors, when the well plugs would leak, and with Carter designs when the sealing ball in the main circuit did not seat properly and allowed fuel to pass. The engine stalls because it is running out of gasoline in the carburetor.

Loads up/blows black smoke after running a few minutes: The choke plate is not opening enough after the engine starts. This can be caused by a misadjusted pull-off, a worn diaphragm in the pull-off that has either torn or has swelled and is not moving enough, or a fast-idle speed that is set too low. It is common to find all of these things wrong with an older carburetor.

Balky during warm-up; may spit/pop through the carburetor when trying to drive: The choke spring tension is not tight enough and the butterfly is opening prematurely, creating an excessively lean air/fuel ratio for the engine temperature. Choke spring tension needs to be made tighter.

Stays on fast idle too long: The choke spring tension is too tight, the heat source is not being supplied or is blocked, or the fast-idle cam is gummed up, bent or has another problem that does not allow it to drop.

A properly set choke circuit will allow the engine to fire immediately on even the coldest day; the fast-idle cam will drop one notch within a few seconds, allowing the transmission to be placed in gear and the vehicle driven away with no hesitation under any load or condition. Anything other than these results, and your carburetor choke is not set properly. By following the steps provided here, your engine will run with the best Detroit EFI system. Believe me, mine do.

Special thanks to Greg Matarrese for the use of his beautiful 1968 Dodge Hemi Super Bee and his assistance with photos.

PHOTO 1 The butterfly should close freely when the engine is cold and the throttle is opened enough to release the fast-idle cam. If not, clean the carburetor and work the butterfly with your hand to loosen it up.

PHOTO 2 Though all choke systems work basically the same, there will be design differences with each model of carburetor. Always reference the

factory shop manual for the adjustment specifications particular to your model.
PHOTO 3 A divorced choke uses a spring housing that is separate from the carburetor body. Some Rochester Quadrajet carburetors employed a divorced choke spring that is very sensitive to intake manifold heat to open the butterfly.
PHOTO 4 An integral choke is one that has the spring attached to the carburetor, as this Carter does. The notch is called the index mark; it is used along with the hash lines on the casting as an adjustment.

PHOTO 5 On most carburetors, the fast-idle speed screw is in an awkward position, but must be adjusted for the proper performance. On later Q-Jets, if the choke spring has any tension, the secondary barrels will not open because of a lock lever that contacts the fast-idle cam.
PHOTO 6 A choke pull-off needs to be checked with a vacuum pump for integrity and the ability to actually move the choke plate with the engine cold and not running. Just because it holds vacuum does not mean that the linkage is moving sufficiently.
PHOTO 7 Most carburetors (right) used a drill-bit index as a gauge for the choke pull-off opening amount thanks to the precision machining to specific dimensions that these common toolbox items offer.
PHOTO 8 More modern Rochester designs (left) employed a choke-angle gauge as a means to determine the pull-off opening amount.
PHOTO 9 To adjust the choke pull-off opening on this Carter Thermo-Quad requires bending the linkage in the kinked area. Some carburetors had a screw adjustment for the pull-off opening rate.
PHOTO 10 It was common for a Q-Jet to have a secondary air valve lockout connected to the choke pull-off. If the diaphragm on the pull-off is weak, the secondary air valve may not be allowed to open even if there is no cold driveability issue.
PHOTO 11 This choke spring from a Hemi with dual-quads works the same as one on a six-cylinder grocery-getter. The bimetallic spring unwinds when heat is introduced, and recoils upon cooling to provide choke linkage activation.
PHOTO 12 An integral choke requires a heat source, usually from the exhaust manifold, piped to it so that the choke opens. If the tube is cracked, the choke will stay on until the underhood temperature becomes very high.
PHOTO 13 Both integral and divorced chokes usually have markings to identify which way to adjust. "Rich" means the choke will stay on longer (it will take more heat to release), while "lean" has less tension and comes off sooner.

PHOTO 14 The lever and piston seen behind the choke spring on this Carter is the "unloader" that will force the butterfly open when the throttle is floored, to start a flooded engine. On this design, there is a feeler gauge adjustment for the unloader movement.
PHOTO 15 To adjust the choke spring tension on a divorced model, the housing is loosened slightly and rotated while referencing the index mark. Most divorced springs also have hash and index marks for adjustment, but will need to be removed from the manifold for adjustment access.

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